

**Final**

**LONG-TERM REVEGETATION  
MONITORING PLAN**  
New World Mining District  
Response And Restoration Project

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Response And Restoration Project

*Prepared for:*

**USDA Forest Service  
Northern Region  
Missoula, Montana**

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## TABLE OF CONTENTS

<b>1.0</b>	<b>INTRODUCTION.....</b>	<b>1</b>
1.1	BACKGROUND .....	1
1.2	SITE LOCATION AND DESCRIPTION.....	2
<b>2.0</b>	<b>PURPOSE AND OBJECTIVES.....</b>	<b>2</b>
<b>3.0</b>	<b>REVEGETATION MONITORING .....</b>	<b>7</b>
3.1	MONITORING LOCATION AND FREQUENCY .....	7
3.2	FIELD NOTES.....	8
3.3	COVER SAMPLING .....	8
3.3.1	<i>Transect Siting</i> .....	8
3.3.2	<i>Sample Designation</i> .....	9
3.3.3	<i>Point-Quadrat method</i> .....	9
3.3.4	<i>35mm Slide Method</i> .....	10
3.3.5	<i>Bitterlich's Variable Radius Method</i> .....	11
3.4	AREA-WIDE MONITORING .....	11
3.5	QUALITY ASSURANCE/QUALITY CONTROL .....	12
3.6	DATA VALIDATION .....	13
	<b>REFERENCES.....</b>	<b>14</b>

### List of Tables

1	Sample Designation Codes.....	9
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### List of Figures

1	Project Vicinity Map.....	3
2	Reclamation Status Map.....	5

### List of Appendices

A	Field Forms
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## **1.0 INTRODUCTION**

This Long-Term Revegetation Monitoring Plan for the New World Mining District (District) was developed by Maxim Technologies, Inc. (Maxim) for the United States Department of Agriculture - Forest Service (USDA-FS).

The USDA-FS is undertaking a non-time-critical removal action in the District to respond to and restore natural resources affected by historic gold, silver, copper, and lead mining. The historic District is located in a 40 square mile area surrounding Cooke City, Montana (Figure 1).

This monitoring plan is one of several project plans and is directly supported by the Site-Wide Sampling and Analysis Plan (Site-Wide SAP) (Maxim, 1999). The Site-Wide SAP contains the methods and procedures for all revegetation monitoring and analysis. The Site-Wide SAP is the overall guidance document for all environmental data collection procedures in the District. The Site-Wide SAP is referenced for standard operating procedures (SOPs) involving quality assurance, quality control, and documentation.

Long-term revegetation monitoring of reclaimed areas will be done annually over the 8-year life of the project to ensure revegetation is meeting project specific performance standards. Monitoring will initially be conducted on about 26 acres of reclaimed disturbed areas and about 9.8 miles of reclaimed roads that have been located in the District as of May 1999 (Figure 2). Through review of reclamation history, additional reclamation areas will be identified. Long-term monitoring will commence on these areas as they are verified. Additional disturbed areas are expected to be reclaimed during each year of the project life. Long-term monitoring will commence on these newly reclaimed areas following the first growing season after seeding has been completed. This monitoring plan establishes methods that will be used in these data collection and reporting activities.

### **1.1 BACKGROUND**

In August 1998, Crown Butte Mines, Inc.(CBMI) entered into a consent decree with the United States Government, the State of Montana and several non-profit organizations which provided funding for, and guidance on, response and restoration actions to be implemented on historic mine related disturbances in the District. At that time, the USDA-FS became the lead agency in the clean up effort. The work, among other aspects, includes evaluating revegetation efforts that have been completed in the past as well as those revegetation projects that will be completed over the expected 8-year life of the project.

Mitigation of historic mining wastes has been an on-going interest of numerous parties since the 1970s. One of the first to investigate revegetation in the District was the USDA-FS Intermountain Research Station (Brown, 1996). This research has focused on reclamation of high elevation mine disturbances and has included species selection, fertilization, planting season, organic amendments, acid soil amendments, and surface soil treatments. Larger scale reclamation efforts have also been conducted by numerous parties involved in reclamation of the McLaren Tailings near Cooke City (Figure 1). In 1969, the Bear Creek Mining Company covered the McLaren Tailings with soil and rerouted Soda Butte Creek. In 1989, the EPA constructed a dam at the lower end of the tailings to stabilize the banks of Soda Butte Creek (UOS, 1998). Other areas of the tailings have been recontoured and revegetated since that time.

Some reclamation work was completed by CBMI on District Properties as part of their exploration and proposed mine development work. In 1993, CBMI began surface restoration work to reclaim the historic McLaren open pit mine disturbance and areas disturbed by exploration activity in the Como Basin. Reclamation activities at the McLaren pit included recontouring, construction of runoff control ditches, treating acid soils with a lime amendment, and fertilizing and seeding with native grasses. Similar reclamation work was completed in the Como Basin area although additional work was done in this area to construct runoff controls to prevent water

from entering a raise connected to the Glengarry adit. From 1993 to 1996, CBMI also reclaimed a number of exploration roads and drill pads.

This monitoring plan will be used initially to commence long-term monitoring of reclamation work completed by CBMI at the McLaren pit and in the Como Basin and on reclaimed exploration roads. As additional reclamation areas are identified through review of reclamation history, monitoring protocols presented in this plan will be applied. This monitoring plan will not be used to continue on-going investigations by the USDA-FS Intermountain Research Station. It also will not be used to monitor reclamation efforts at the McLaren Tailings near Cooke City. However, long-term monitoring will commence on revegetation projects that will be completed over the expected 8-year life of the project

## 1.2 SITE LOCATION AND DESCRIPTION

The District is located in Park County in south-central Montana. It is bounded on the south by the Montana-Wyoming state line, on the west by Yellowstone National Park and on the north and east by the Absaroka-Beartooth Wilderness area boundary (Figure 1). The District is characteristic of high alpine regions of the northern Rocky Mountains with elevations that range from approximately 7,000 feet to over 10,000 feet. Accumulated snow pack in the higher elevations range from 10 feet to over 20 feet deep where drifting occurs. The ground is generally snow covered from late October through mid May at the lower elevations and from early October through late July at the higher elevations. Perennial and semi-perennial snow fields occupy the north facing slopes of the highest mountain peaks.

Three drainage basins have been identified as potentially being impacted by the proposed response and restoration actions: 1) Fisher Creek and the Clarks Fork of the Yellowstone River; 2) Daisy Creek and the Stillwater River drainage basin; and, 3) Miller Creek and Soda Butte Creek drainage basin.

Predominant native vegetation communities in the project area include upland forest types, upland herbaceous and shrub types, bottomland types, and avalanche complex types. Upland forests generally predominate below 9600'; however, several types composed of whitebark pine (*Pinus albicaulis*) and subalpine fir (*Abies lasiocarpa*) extend into mid and upper slopes above this elevation primarily on southerly slopes. Several upland herbaceous and shrub types exist, their distribution determined by factors such as elevation, slope, aspect, topographic position, and soil characteristics. Bottomland forests extend along riparian areas throughout the project area, increasing in tree cover with decreasing elevation. Avalanche areas are present in upper Fisher Creek and at the head of other drainages. Vegetation communities vary with intensity and frequency of snow movement, topographic features, and soil characteristics (Scow et al., 1992).

## 2.0 PURPOSE AND OBJECTIVES

The purpose of revegetating disturbed areas in response and restoration is to provide an effective erosion control measure and to produce a self-sustaining vegetation community that reflects the natural conditions of the undisturbed, native communities in the District. The primary purpose of revegetation monitoring is to ensure that these objectives are being met and to provide a mechanism to take corrective action if the objectives are not being met. To this end, long-term revegetation monitoring will consist of the following: collecting annual data over the life of the project on existing and newly reclaimed areas; documenting trends in vegetation parameters over time; identifying areas where revegetation may be failing; and providing recommendations for maintaining revegetated areas.

Figure 1 - Project Vicinity Map

Figure 1 - back page

Figure 2 - Reclamation Status Map (in progress)



Figure 2 - back page

### 3.0 REVEGETATION MONITORING

Revegetation monitoring will include both cover sampling and area-wide observations. Cover sampling will use the following methods described in Chambers and Brown (1983): Point-Quadrat Method, 35mm Slide Method, and Bitterlich's Variable Radius Method. Data collected in cover sampling will be used to report cover, species composition, species diversity, species density, and species frequency. Area-wide monitoring will be conducted on the major reclaimed areas to: 1) record the number, size, and location of revegetated areas bare of vegetation; 2) record the presence, size and extent of erosional features such as rills and gullies; and 3) assess the cause for the lack of vegetation.

An annual monitoring report will be prepared following each field season and after receipt of any analytical data to summarize the results of revegetation monitoring. These reports will contain a summary of the work completed, any deviations from procedures specified in this plan, tabulated data, appropriate statistical analysis, recommendations for maintaining revegetated areas and areas where revegetation may be failing, and appended field sheets and laboratory analytical reports.

This section describes monitoring locations and frequency, field notes, sample designations, sampling and reporting methods, quality assurance/quality control, and data validation of monitoring events associated with this data collection.

#### 3.1 MONITORING LOCATIONS AND FREQUENCY

Revegetation monitoring will be conducted annually timed to coincide with the mature phenological stages of the majority of species under investigation. In most years, this time period begins at the end of July and persists for about one month. Specific monitoring dates will be determined each year depending on field and weather conditions and the phenological variability of the areas being monitored.

Reclaimed areas will be stratified to accommodate statistical analysis with respect to ecological factors such as slope, aspect, moisture regime, soil types, and elevation. By stratifying, variability can be reduced, thus allowing less uncertainty in the statistical analysis and providing more meaningful results. As of spring 1999, there are three distinct reclamation areas in the District, two of which can be further stratified. A brief description of these areas, and their proposed stratification, follows:

- McLaren Pit                      The McLaren Pit is the largest contiguous reclaimed area in the District comprising an area of about 24 acres. It is located in the headwaters of the Stillwater River on the north side of Daisy Pass (Figure 2). It will be stratified into three groups, based on ecological factors: 1) the upper level, an area located north of the mined high wall; 2) the lower area, an area down slope of the mined high wall; and 3) the southern triangle, about four acres, characterized by protected conditions.
- Como Basin                      The Como Basin is about six acres of reclaimed land located in the Fisher Creek watershed on the south side of Lulu Pass. It will not be stratified for data collection purposes.
- Reclaimed Roads              Ten to 12 miles of reclaimed roads occur in the District, the majority of which are located on Fisher and Henderson Mountain. Reclaimed roads will be stratified into three groups, based on elevation and slope, rockiness, and tree cover: 1) roads on exposed, steep scree slopes at

elevations generally above 9900'; 2) roads at elevations generally between 9600' and 9900' with lower rock content, gentler slopes, and scattered tree cover; and, 3) roads below about 9600' in heavier cover.

Proposed strata boundaries in the McLaren Pit will be field verified, flagged, and surveyed with a resource-grade Global Position System (GPS) instrument according to Maxim Standard Operating Procedure (SOP) 41. As additional reclamation areas are identified through review of reclamation history, this system of stratification will be applied. This same system of stratification will be used for newly reclaimed areas that are added into the monitoring program.

## 3.2 FIELD NOTES

All field observations will be recorded in a project dedicated field notebook in accordance with Maxim SOP-12 (Sample Documentation). The standard project field books that will be used by all personnel will be the equivalent of the pocket-sized "Rite in the Rain"® All-weather Transit Notebook No. 301 (4 5/8 x 7" with numbered pages). Each field book will be labeled on the front cover with the project name, beginning entry date, final entry date, and general contents of notes (e.g., 1999 revegetation monitoring). Area-wide monitoring and cover sampling data will be recorded on field forms such as those included in Appendix A.

The field team leader will be responsible for recording information such as weather conditions, field crew members, visitors to the site, samples collected, the date and time of sample collection, procedures used, any field data collected, and any deviations from the methods and procedures presented in this monitoring plan. The field notebook will be the master log of all field activities. As such, in addition to standard field notations (e.g. field conditions, date, time, weather, field personnel, sample station number, etc.), information entered into the field notebook will also include a daily log of the number and type of measurements taken, the number of samples collected each day, sample packaging and shipping summaries (i.e. number and type of shipping containers, shipping carrier, date and time of shipment, etc.), and any other information relevant to the field event.

## 3.3 COVER SAMPLING

Cover sampling will use the following methods described in Chambers and Brown (1983): Point-Quadrat Method, 35mm Slide Method, and Bitterlich's Variable Radius Method. Each method will use transects that will be established in reclaimed and undisturbed areas. In reclaimed areas other than roads, samples transects and sample locations will be located to represent a one-dimensional "square grid" pattern as described in Cochran (1977). Measurements of plant parameters will be taken along these transects. This section describes transect siting, sample designations, and field methods for each cover sampling method.

### 3.3.1 TRANSECT SITING

Transects will be sited randomly within each monitoring strata. Transects will be located in reclaimed areas using random starts and will be randomly oriented. Sample locations along these transects that fall within research plots will not be sampled. Reclaimed road transects will be sited by dividing roads within each strata into segments, assigning a numerical value to each segment, and randomly selecting segments to monitor. Transects will be established in a similar manner within reference areas. Reference (native) areas will be selected according to criteria noted in Chambers and Brown (1983). With the exception of road transects, each transect will be permanently marked and surveyed with a resource-grade Global Position System (GPS) instrument according to Maxim SOP 41.

A suitable sample intensity will be used each year supporting statistical treatment of the data to ensure revegetation is meeting project specific performance standards. Sample size will be determined by the variability of the population being sampled, site conditions, and level of effort. Stratification of reclaimed areas should help control sample variability and sample sizes. In the annual report, recommended adjustments to sampling intensity will be made in order to meet overall project objectives. Approaches to meeting statistical requirements in Chambers and Brown (1983) will be referenced.

Initially, a total of 60 cover sample locations per monitoring stratum are proposed (50 in reclaimed areas and 10 in native). Transects will be located in each of the three strata at the McLaren Pit, and within the the Como Basin, to meet this target. Five transects, with ten sample locations each, will be located in each of the three reclaimed road strata. Three similar reference transects will be established in undisturbed native areas with similar slope and aspect adjacent to each of the reclaimed strata at the McLaren Pit, one similar transect will be established adjacent to the Como Basin, and one similar parallel reference transect will be established in adjacent, undisturbed native areas next to each of the reclaimed road transects. These proposed sampling intensities may be adjusted in consideration of population variability, site conditions, and level of effort.

### 3.3.2 SAMPLE DESIGNATION

The sample designation (number) consists of letters and digits. An example sample number is RR-99-MUR11. The first two letters are the project identifiers for Response and Restoration (RR). The next two digits refer to the year collected (99), followed by the next three letters which refer to the area being sampled (MUR), representing the reclaimed area, strata, and reclaimed/native pairing. The last two digits refer to the transect and station number (11). Table 1 shows the codes that follow the year designation.

<b>TABLE 1</b> <b>Sample Designation Codes</b> <i>Long-Term Revegetation Monitoring Plan</i> <i>New World Mining District - Response and Restoration Project</i>				
Reclaimed Area	Strata	Transect Pair	Transect No.	Station No.
M = McLaren Pit	U = Upper Half (North) L = Lower Half (South) T = Southern Triangle	R = Reclaimed N = Native	1, 2, 3, 4, ...	1, 2, 3, 4, 5, 6, ...
C = Como Basin	W = Whole Pit Area	R = Reclaimed N = Native	1, 2, 3, 4, ...	1, 2, 3, 4, 5, 6, ...
R = Roads	U = Upper Elevation M = Middle Elevation L = Lower Elevation	R = Reclaimed N = Native	1, 2, 3, 4, ...	1, 2, 3, 4, 5, 6, ...

### 3.3.3 POINT-QUADRAT METHOD

The Point-Quadrat Method will be used to report cover, species composition, species diversity, species density, and species frequency in herbaceous and shrubby vegetation. Cover and density will be recorded in the field on a species basis. Species frequency and diversity will be calculated from these data.

Transect length and quadrat size will be chosen to accommodate site conditions and permit meaningful statistical evaluations of the data. In reclaimed areas, transect spacing and sample locations along transects will represent

a square grid. Additional transects may be established to achieve sample size targets. Initially, transects will be 30 meters long and cover data will be collected at 10, 0.25 square meter ( $m^2$ ), rectangular quadrats. The 0.25  $m^2$  quadrat will be placed systematically every three meters on alternate sides of the 30 meter transect beginning at the 3 meter mark and ending at the 30 meter mark. If the 0.25  $m^2$  quadrat size is found to provide inadequate coverage in sparse vegetation, larger quadrat sizes will be considered.

Ground cover is the area covered by vegetation, litter, and rock expressed as a percentage of the total area of measurement. A modified point intercept method described in Chambers and Brown (1983) will be used to sample cover within each quadrat. This involves suspending a grid with ten points over each quadrat and collecting cover data for each point intercept. Cover will be recorded for each species or as bare ground, rock, or litter. Initially, six hundred points per strata will be recorded (500 along reclaimed transects and 100 along native); however, larger sample sizes may be considered to support meaningful statistical evaluation.

Species density will be recorded and calculated as a measure of the number of plants per unit area. Density provides a consistent measure of stocking rate from year to year. Individual quadrat values summarized by species will be used for calculating species density for each monitoring strata.

Species frequency will be calculated as a measure of the number of times a species is present per sample size. Frequency provides an index to detect changes in species composition. Individual quadrat values summarized by species will be used for calculating species frequency for each monitoring strata.

Species will be recorded using a six letter code comprised of the first three letters of the genus and the first three letters of the species. Vascular plant nomenclature used will be based on *Vascular Plants of Montana* (Dorn, 1984). The vascular plant species will be compared to the District Vascular Plant Species List: 1996 (Brown, 1996). New species will be noted and included in the annual monitoring report.

Species diversity will be calculated to express species richness and species evenness. Diversity will be used as an index of the number of species and their relative abundance within monitoring strata. Several measures will be considered as described in Chambers and Brown (1983), including: Shannon's Diversity Index, Spearman's Rank Order Correlation Coefficient, and Similarity Indices. Species richness curves will also be considered. All measures will be determined using the frequency data compiled for each quadrat.

#### 3.3.4 35MM SLIDE METHOD

The 35mm Slide Method will be used to document transect location and provide a reference for cover in herbaceous and shrubby vegetation on reclaimed transects in the McLaren Pit and Como Basin strata. Individual sample quadrats will be photographed in the field and cover determined from the developed slide.

Quadrat photos will be taken on a subsample of the sampling locations used in the Point-Quadrat Method. Initially, one transect per monitoring strata will be randomly selected. One picture will be taken along the transect length to document transect location. Along this transect, three quadrats will be systematically photographed at the 9, 18, and 27 meter marks. Consideration will be given to increasing photo stops if these provide insufficient information to support the overall project objectives.

A suitable tripod and camera bar will be used to position the camera over the center of the quadrat. The size of the camera lens will be determined by the size of the quadrat, and the focus, lens aperture, and shutter speed will be adjusted for each quadrat and the photograph taken. Individual quadrats will be labeled according to the location, date, transect, and quadrat number.

After development, slides will be projected onto a grid of 100 squares to determine cover. At a minimum, the number of grid squares covered by vegetation, bare ground, rock, or litter will be counted. If vegetation is sparse, attempts to record vegetation by species will be made. Cover will be calculated as a percentage of area covered and compared to cover estimates derived from the Point-Quadrat Method. To ensure unbiased results, the field personnel used in the Point-Quadrat Method will not interpret the slides.

### 3.3.5 BITTERLICH'S VARIABLE RADIUS METHOD

Bitterlich's Variable Radius Method will be used to report tree cover, species composition, and species density in strata where trees have measurable diameter at breast height (DBH). These conditions are anticipated at lower elevations. Trees will be tallied in the field on a species basis using point angle gages. Species cover, composition, and density will be calculated from these data.

Transect length and basal area factors will be chosen to accommodate site conditions and permit meaningful statistical evaluations of the data. Initially, transects will be 30 meters long and cover data will be collected at 3 points using a basal area factor (BAF) of 10. Points will coincide with quadrat sample stations described above. Adjustments to transect length, sample size, and BAF selection will be made if they are found to provide inadequate coverage supporting meaningful interpretation of the data.

Tree cover will be recorded as the stem basal area on a per unit area basis. Bitterlich's Variable Radius Method described in Chambers and Brown (1983) will be used to sample basal area at each sample point. This involves tallying trees subtended by the angle gage. Tallies will be recorded on a species basis by 2 inch diameter class. Basal area will be calculated from these data.

Species will be recorded using a six letter code comprised of the first three letters of the genus and the first three letters of the species. Vascular plant nomenclature used will be based on *Vascular Plants of Montana* (Dorn, 1984). The vascular plant species will be compared to the District Vascular Plant Species List: 1996 (Brown, 1996). New species will be noted and included in the annual monitoring report.

Species density will be calculated as a measure of the number of trees per unit area. Density provides a consistent measure of stocking rate from year to year. Individual point values summarized by species and size class will be used for calculating species density for each monitoring strata.

## 3.4 AREA-WIDE MONITORING

The purpose of area-wide observational monitoring of reclaimed areas is to identify areas that require maintenance. Area-wide observational monitoring will be conducted on the entire major reclaimed areas to record the number, size, and location of revegetated areas bare of vegetation and, the presence, size and extent of erosional features such as rills and gullies. Area-wide surveys will also be done on reclaimed roads to the extent feasible in consideration of site conditions and level of effort. A minimum of at least half the total miles of reclaimed roads will be monitored in this manner.

Criteria used to determine if an area is barren will be: 1) areas that are approximately 10 percent or more of the monitoring strata; and, 2) areas where reclamation treatment has clearly failed. These criteria would be applied in the McLaren Pit, Como Basin or other historic or newly reclaimed areas added to the monitoring program. For roads, criteria used will be: 1) areas that are 10 percent or more of the reclaimed segment; and, 2) areas where significant erosion or slope stability concerns are associated with lack of vegetation. For recording erosional features, a minimum size criterion will not apply; rather, the criterion for noting erosional features will be determined by field personnel if erosional features dominate the character of the reclaimed areas. Areas that appear to be bare will be generally located using a GPS instrument.

Observations of barren reclaimed areas will include an assessment of the cause for the lack of vegetation and recorded on field sheets. Factors to note may be the appearance of salts, steepness of slope, pooling of water, seeding failure, or other soil inhibiting factors. Reclamation practices (e.g., road re-contouring, erosion mats) that may be affecting performance will also be noted. Field assessment will include photo documentation and a generalized site map. Soil samples will be collected in areas without vegetation according to methods presented in the Site-Wide SAP.

Soil samples will be collected to a depth of approximately 15 cm and a minimum sample of 300 grams will be placed in 1-gallon polyethylene bags. Samples will be labeled by location and returned to a qualified laboratory for selected analyses in accordance with the parameters and methods in the Site-Wide SAP for native soil collection. Laboratory parameters may include USDA soil texture, coarse fragment content, pH, electrical conductivity, organic matter, nutrients, and total metals (aluminum, arsenic, cadmium, copper, lead, and zinc). Sample collection and parameter selection will be performed at the discretion of the field investigator to ensure site-specific conditions are being addressed and overall project objectives are being met.

After receipt of the laboratory analysis, recommendations will be made to amend soils or reseed the barren areas. Reclamation maintenance will either be performed in the same field season that the data become available during the dormant fall seeding window or will be done the following year.

In addition to the area-wide assessment, whitebark pine trees planted below the Little Daisy Adit as part of previous reclamation efforts by CBMI will be observed for new growth, mortality, and whether protective coverings installed during the planting phase are restricting growth and should be removed.

### 3.5 QUALITY ASSURANCE/QUALITY CONTROL

The elements of quality assurance/quality control (QA/QC) for revegetation monitoring will include the following:

- Long-Term Revegetation Monitoring Plan (this plan)
- Field documentation of data collection and sampling procedures
- Properly prepared chain of custody records
- Quality control blanks, duplicates and splits for any laboratory analytical work
- Proper identification of analytes
- Quantification of analytes within acceptable error limits
- Matrix spike recoveries and documentation
- Statistical evaluation of data

For all field observations, QA/QC will primarily rely on the expertise and professionalism of the field crew collecting the data. Photographic monitoring of the record transects will be used to compare the field derived data with species and cover data viewed in the slide. This information will be used to assess the precision of the field sampling method.

If soil samples are collected, QC samples will be collected in accordance with the Site-Wide SAP and SOP-13 (QC Samples). The following QC samples will be collected for soil sampling:

- *Field duplicates* - 1 per sampling event or 5% of total number of samples collected.

Chain-of-custody forms will accompany each cooler to the laboratory. Chain-of Custody forms will be filled out to include the project name, samplers name, sample number, date and time of sampling, number and type of sample containers, and analytical parameter and method list.

### 3.6 DATA VALIDATION

Revegetation monitoring data will be entered into the project database after field data collection has been completed. To ensure that data are correctly transferred from the field forms into the database, 10% of the data will be independently checked and verified.

Laboratory analytical data, if collected, will be directly downloaded from the laboratory into the project database. Data flagging, accuracy, and precision will be done in accordance with procedures specified in the Site-Wide SAP.



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